Review of 'The role of atmospheric large-scale patterns for recent warming periods in Greenland'

In this study, Schalamon et al. present a comprehensive analysis using a long-term observational dataset from Greenland combined with weather pattern clustering based on reanalysis data. The authors identify two distinct warming periods evident in observational records and supported by reanalysis data. The study uses Self-Organizing Maps (SOM) to investigate the role of changes in circulation patterns on warming periods and temperature anomalies. The study uses well established methods applied over centennial timescales, which sets it apart from other studies that typically focus on the satellite era. The questions that are addressed are relevant for the journal's scope and contribute to understanding the impact of changes in atmospheric circulation on Greenland climate and SMB. The figures in the manuscript are presented well and clearly. My comments are mostly around sensitivity of the results to choices in setting up the SOM. Furthermore, the manuscript could be strengthened by adding further interpretation of the results of the LSPs and their link with warming anomalies, and bringing these in context with known modes of variability and synoptic circulation features in the Arctic.

Main comments

- It is unclear from the introduction and methods why the WEG_L site is chosen as study area for the AT anomaly analysis. Further motivation is needed in the introduction or methods to clarify why the authors choose to link this analysis with the dataset described in Abermann et al. (2023).
- Are the SOM results dependent on seasonality in the geopotential height field? Previous studies (e.g., Cassano et al., 2015) suggest that using spatial anomalies instead of absolute fields can remove seasonal signals, focusing SOM analysis on gradients in geopotential height that drive advection.
- It is interesting that in LSP3 both positive and negative anomalies occur. Could the small number of clusters have resulted into several patterns being averaged into the zonal pattern shown in LSP3? Have the authors tested the results by training a larger SOM and seeing if those positive and negative anomalies still occur from a zonal pattern?
- It would be valuable to add whether warming trends in WP1 and WP2 show seasonal variation. Are certain seasons contributing more than others to the observed trends?
- I would suggest to add an additional figure in which the LSP occurrence per year is given for the full study period. This could show potential shifts in LSP occurrence in the cold period before the WP versus the warm period after that could explain the WP patterns.

- Is there seasonality in LSP occurrence over the full period? In that case I would suggest instead of showing relative changes during WPs, Fig. 5 could show absolute occurrences of LSPs across both the overall as well as the warming periods.
- Looking at the similarity in relative occurrence of the LSPs between the different periods I am surprised the distribution of LSPs is significantly different. Can the authors explain why a Chi-Square test is used and if this result would be robust with other significance tests?
- The manuscript could be strengthened by some further interpretation of the results from the SOM analysis and linking these with known modes of variability. For example, do the node occurrences correlate with the Arctic Oscillation or NAO? Could high occurence of LSP3 reflect conditions of strong polar vortex with less meandering, in which the Arctic and Greenland are often colder (agrees with Fig. 6. which is often during the positive phase of AO). During opposite conditions the polar vortex is weaker and weavier patterns form in the geopotential height field, which might explain the patterns detected by the other LSPs.
- The discussion could be strengthend by comparisons with studies linking extreme warming/melt events in Greenland to atmospheric conditions (e.g., Fettweis et. al 2013, Neff et. al, 2014, Hermann et. al, 2020)

Specific comments

Title: Consider including the study period to highlight the long temporal scope of the study.

L. 37: Without reading Abermann et al. 2023, it is unclear from this section what is meant with ‘high-resolution observations’.

L. 65: add ‘summer’ after ‘from the west’.

L. 80: Can you add more information on the weather station data, such as measured variables and presence of data gaps, or refer to the source for these details.

Sect. 4.1: The warming periods are based on significant warming trends in the weather station data. Are the trends in reanalysis over the same periods significant as well? For example, in Fig 2b doesn’t look significant at the study site location.

Fig 2: Include the study site location also in Fig 2b.

L. 197: The Arctic doesn’t seem to warm during this period, so rephrase to ‘concentrated over Greenland’ to also agree with your following statements.

L. 225: Can you clarify this statement? Often SOMs are shown as matrix in which neighboring nodes are most similar and further away nodes most different. In case of atmospheric circulation patterns neighboring nodes could be transitional from one synoptic state to another.

L. 315 – 320. This section would fit better in Methods section 2.2

L. 367: The difference in warming through LSP6 (dominantly in winter) and LSP3 (dominantly in summer) is interesting and could have more discussion here. What is the role of advection from continental vs oceanic regions? This could explain why in winter there is more warming during LSP 6 (relative warm ocean) and in summer warming from continental sources (LSP3).

References

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